34

157313

申請日期	79 . 2 . 2
案號	79100720
類別	H01L (以)

（以上各欄由本局填註）

公告本

A4
C4

發明/新型 專利說明書

一、發明/創作名稱	中文	「在酸處理器中用氫氟酸氣體蝕刻晶片之方法」
	英文	"HF GAS ETCHING OF WAFERS IN AN ACID PROCESSOR"
二、發明/創作人	姓名	1. 丹尼爾・傑・西佛森 DANIEL J. SYVERSON 2. 理查・伊・諾華克 RICHARD E. NOVAK
	籍貫(國籍)	（皆）美國
	住、居所	美國明尼蘇達州羅賓涉載市北比德街4210號 美國明尼蘇達州普利茅斯市方登街2000號
三、申請人	姓名(名稱)	美商文福斯埃國際公司 FSI INTERNATIONAL, INC.
	籍貫(國籍)	
	住、居所(事務所)	美國明尼蘇達州查士卡市約拿散工業中心湖哈士汀街322號
	代表人姓名	理查・哈・賈克森 RICHARD H. JACKSON

（請先閱讀背面之注意事項再填寫本頁各欄）

裝

訂

經濟部中央標準局印製

157313

A5
B5

四、中文發明摘要（發明之名稱：在酸處理器中用氫氟酸氣體蝕刻晶片之方法 ）

利用氣相蝕刻以無水氟化氫氣體在晶片載體內晶體間流動分批處理半導體晶片。蝕刻可在一盤內進行，晶片載體裝在密閉盤內一轉片上。蝕刻劑可含少量水汽與無水氟化氫氣一起，因開始蝕刻製程時可能須要。安排晶片於晶片載體內堆架中並沿旋轉軸或在其上可進行蝕刻。

英文發明摘要（發明之名稱：HF GAS ETCHING OF WAFERS IN AN ACID PROCESSOR ）

Batch processing of semiconductor wafers utilizing a gas phase etching with anhydrous hydrogen fluoride gas flowing between wafers in a wafer carrier. The etching may take place in a bowl with the wafer carrier mounted on a rotor in the closed bowl. The etchant gas may include a small amount of water vapor, along with the anhydrous hydrogen fluoride gas, as may be needed to commence the etching process. The etching may take place with the wafers arranged in a stack in the wafer carrier and extending along or on the rotation axis.

附註：本案已向 美 國（地區） 申請專利，申請日期：1989.4.7 案號：334,343

（請先閱讀背面之注意事項再填寫本頁各欄）

裝 訂 線

經濟部中央標準局印製

甲4(210×297公釐)

78. 8. 3,000

五、發明說明（1）

本發明係關矽晶片之氣體蝕刻，較詳言之係關裝在線型晶片載體內並在封閉室中旋轉之此項分批晶片蝕刻。

發明之背景

電路晶方製造中半導體矽晶片之頻處理時晶片表面上氧化物層或膜之蝕刻為處理的重要特色。

以往晶片處理多用濕蝕刻法，包括限制在能耐強烈化學品如酸類的塑膠製晶片載體內的矽晶片上噴霧以液態酸及其他液態化學品與脫離子水。

一個或多個此等晶片載體裝在一酸處理機的密閉盤內之變速轉盤或轉片上。此項機器對其操作有許多可變相，包括轉片速度變化、連續噴霧各種液態處理化學品、及氮氣供乾燥晶片、各項濕處理相關盤與轉片。美國專利 3,990,462 中示範說明一種酸處理器形式。美國專利 4,609,575; 4,682,615 及 4,691,722 等亦見濕蝕刻法用噴嘴排列與其他設備之變化等。美國專利 4,682,614 中亦見一近於臥式的機器。

矽晶片曾經用某些氣體的電漿完成蝕刻。美國專利 3,879,597 內曾發表許多晶片同時用電漿技術蝕刻。

有些早期工作用氣態 HF/H_2O 分批蝕刻 SiO_2 經 K.D. Beyer 與 M.H. Whitehill 在 IBM Technical Disclosure Bulletin, Vol.19, No.7, 1976 年 12 月號內發表。淺盤中許多晶片置放 HF 溶液上，在 DI－水中沖洗，最後浸入硝酸液。

近年來曾用無水氟化氫氣達成蝕刻矽晶片上的氧化物膜

，見美國專利4,749,440。蝕刻劑氟化氫氣常以乾氮氣稀釋。少量濕度隨意為水汽與氟化氫氣混合或在待蝕刻的氧化物膜含有係必須存在以與膜內氧化物反應俾起動蝕刻程序。

此項矽晶片上氧化物膜之以往氣相蝕刻在設計進行僅一晶片之室內每次僅在一片晶片上完成。見前述美國4,749,440專利並參閱1989 年3月2日提出與本申請案共有者在美國專利及商標局之申請案S.N. 020,473

發明之概要

本發明之目的在改進半導體晶片之分批氣態蝕刻以除去表面上至少一部份氧化物膜或層以促進此項晶片之更快處理。

本發明之特色為半導體晶片之分批處理法，包括利用氣態含無水氟化氫蝕刻劑在一密閉室內蝕刻其上一部份氧化膜或層。

本發明之另一特色為此法處理裝在晶片載體內的眾多矽晶片，曝露晶片於蝕刻劑氣體，同時晶片與載體於一酸處理機之密閉室內在轉盤或轉片上旋轉以脫除晶片上氧化物膜部份。晶片由其背面鄰接周緣支承，自所有沿晶片載體內鬆堆晶片的來源噴霧。無產生電漿氣體之電漿存在。

獲得之優點為可同時蝕刻許多半導體晶片而保持在其普通裝載及輸送的晶片載體內，而且改進的氣相蝕刻可在原已可用的設備及晶片處理公司之製造工場中完成。

此外所用〃蝕刻氣〃一辭計劃包括蝕刻晶片表面上部份

氧化物膜或層使用之一切氣相化學品，此項化學物可包括活性氣態化學品如無水氟化氫氣、一稀釋劑氣如氮氣，及有些例案中若晶片上膜或氧化物層內不含水氣時少量水蒸汽式之水份。

圖之簡單說明

圖1為一酸處理機之透視圖。

圖2為透過一型酸處理機的盤與轉片之剖視圖，此機能沿轉片或轉盤的周圍攜帶許多晶片載體。

圖3為另一型能實行本發明用酸處理機的空盤之俯視平面圖，顯視單一晶片載體帶堆架的晶片位置於旋轉軸之實質同心處及其上。

圖4為於圖3的4－4附近所取之部份詳細剖視圖。

圖5為另一型能完成本發明用酸處理機的正視圖，其盤與轉片配置與水平成輕微角度致使旋轉軸近於水平。

圖6為一晶片載體之詳細部份側邊正視圖，載體支持根據本發明經處理的晶片。

詳細說明

圖1與2大概示範一種酸處理機能用以實現文內所述方法，酸處理機10係屬按裝及携帶衆多晶片載體或晶片卡11與旋轉軸成間隔關係，其中携帶晶片成圍繞旋轉軸軌道。

圖3與4說明一不同型酸處理機一般用數字12指示，安裝一晶片載體11或圖示11.1，約在機器之旋轉軸上。

圖5示範之第三型式中數字13指示之酸處理機能用以完成文內所述方法，在此例中晶片載體11裝在轉片14上繞軸

15旋轉，此軸接近水平但與水平成一微角。此三型酸處理機皆能用以完成文內所述方法。

圖1與2說明之酸處理機內機器10納入盤16界定一處理室17，由蓋18封閉。盤與蓋較佳塑膠製如Teflon PFA，惟可用不銹鋼製。此型中轉片19亦可用Teflon PFA或不銹鋼製，界定眾多隔間20，對稱地佈置在轉片19的邊緣周圍並等距離自轉片之旋轉軸，此軸支承於軸21上裝在軸承22內。轉片19之隔間20由頂板23與底板24連接一起，其大小在容納並封閉如此一裝載矽晶片25的晶片載體11。矽晶片排列在堆架內，其中每一晶片與鄰接的晶片對齊並面對面，又其中每一晶片配置橫對轉片19的旋轉軸而垂直。其中晶片載體11及晶片25隔離旋轉軸而隨轉片繞旋轉軸旋轉。

圖6中可見晶片載體本質上留細長孔、開口或有小孔且有敞頂26，當按裝在機器的轉片19而直立時構成載體之正面。晶片載體11係PFA Teflon製，或者稱作全氟烷氧溶融可加工的塑膠，對強烈化學品如酸類之破壞影響具高度抗性，於載體的向內分枝的較低部份28之間亦有一敞開的底27用以支承晶片於凹構29中構成帶進晶片載體之晶片用底座。數溝29間有許多肋條或齒30自較低部份全部向上延伸通出側壁於是保持晶片相互成間隔而對齊的關係。其中納入齒或肋30之側壁設有許多長孔32以便利蝕刻劑氣通過晶片載體而得以接近限制於其中的晶片25。晶片載體11放進轉片時晶片的背面由肋條30在其邊部處支承使晶片的整個正面或上面暴露於室17之氣氛並實質暴露載體背面之所

157313

五、發明說明（5）

有部份於室17內的氣氛。

晶片載體11亦有一端壁包括橫桿33可有任何多種構態，且可有突緣34使其加強。橫桿33伸展完全橫越晶片載體，側壁31可用擋板35相對橫桿以加強。

圖2內所見機器10內一中央噴霧柱36自蓋18中伸出，於近轉片19之旋轉軸處向下並沿晶片載體及其中晶片25之堆架沿伸。噴霧柱內有許多噴嘴37引導製程氣體包括蝕刻劑氣於晶片隨轉片在盤16內旋轉時於其上。蝕刻氣與其他氣體經集管37.1供應，連接至數氣體管線38，38.1，氣體經其供應至噴嘴37噴霧於晶片上及沿盤內晶片堆架之全長。

轉片由變速馬達39驅動，連接於由皮帶40傳動的軸21。以此形式軸管21內有流通21.1供送交流體入歧管42與噴嘴43。此等噴嘴43特別適用於須要時引導清洗或清潔用流體如脫離子水等供室17用及乾燥氣體如氮以確保處理期間盤16的內部維持乾燥。排氣風筒44設置以排出室17之廢氣使須要時可供應不斷氣流。排水管45亦設置以除去可能須要的某些清潔作業期間之清洗或清潔用流體。

須知當晶片載體11裝在轉片上時晶片25相互由空間25.1隔開使氣體可送過晶片表面以達成蝕刻程序。

晶片載體11與美國專利3,961,877中說明者相似，但應了解此機器內可用其他類似載體以實現所述及文內申請之製程。

明細蝕刻過程在美國專利4,749,440中敘述相當詳盡，本文引作參考，不須贅述以了解本發明。蝕刻氣體經噴嘴

157313

五、發明說明（6）

銳孔37供應引向晶片25各邊，經過晶片中間隔25.1橫越晶片表面而完成各晶片面上氧化物之蝕刻。載體11中所裝許多晶片同時完成蝕刻因噴霧柱36中有許多散發氣體之位置，圖中可見沿噴霧柱36表面排列成行的銳孔37。當然當轉片轉動時圍繞轉片19周邊間隔的幾個載體11中之晶片將逐漸接受由中央噴霧柱散發的蝕刻氣噴霧。

以下表I報告在一大致與圖2相似的酸處理器內進行氣相蝕刻所得結果。

表1
試驗概要

試驗	時間	N_2 1/分鐘	水汽 cc/分鐘	HF /分鐘	除去的氧化物	轉速 /RPM	%CV	粒子	殘餘
1	5.0'	7.51	3.01	125cc	全除			2292	有
2	4.0'	7.51	3.01	125cc	全除			2572	有
3	3.0'	7.51	3.01	125cc	全除			1585	有
4	1.0'	7.51	3.01	375cc	全除			678	有
5	20"	7.51	3.01	375cc	269A	(25)	9.3	437	無
6	20"	7.51	3.01	375cc	243A	(17.8)	7.3	311	無
7	20"	7.51	3.01	125cc	36A		1.7	744	無
8	20"	7.51	3.01	125cc	21A		0.8	554	無
9	40"	7.51	3.01	125cc	108A	(5.8)	5.4		無
10	20"	7.51	1.51	125cc			No Etch		
11	60"	7.51	1.51	125cc	270	(27)	10.0		無
12	20"	15.01	1.51	125cc			No Etch		
13	60"	15.01	1.51	125cc	879	(111)	12.7		有
14	60"	15.01	1.51	125cc	491	(107)	21.9		有

圖3及4中說明相似但稍異形式之處理機器及用一稍異形式之晶片載體11.1。此晶片載體11.1另有細長孔32.1

五、發明說明（7）

與32.2使晶片載體之側壁極為多孔以提供最小限制予噴霧蝕刻氣體之流動。晶片載體11與11.1可在此處說明的幾型機器內交換使用。在圖3處理機形式中可見以與圖2內晶片載體實質相同的形式支承，晶片隨載體11.1旋轉如箭頭"a"所指圍繞旋轉軸46沿堆架中配置的晶片伸展並通過之。盤47亦有蓋48用以關閉內室49。蝕刻氣霧可自噴嘴50,51等中一個或多個散發，沖洗此室中稀釋氣亦可經文內所述噴嘴50等之一嘴供應。由圖3式處理機中可見晶片25隨載體11.1旋轉如箭頭"a"所指圍繞旋轉軸46沿堆架中配置的晶片伸展並通過。盤47亦有蓋48關閉內室49。蝕刻氣霧可自噴嘴50.，51等中一個或多個散發，沖洗此室中稀釋氣亦可經噴嘴50之一供應，膜或層可在晶片的面上。

設置風筒53使氣體得以視需要逸出而提供循環，又設置排水管使能放出清洗室內用之液體。但應認知在用氣相蝕刻處理之普通過程中不常用液體噴霧於晶片上。不過有些例案中可繼以脫離子水噴霧脫除細粒。

圖5說明的形式中配置盤55於接近水平位置以接納轉片14之旋轉軸15。一能開　的蓋56幫助獲得進入盤或室57之內部。又晶片25定位於沿旋轉軸15之堆架中，此例中晶片為旋轉軸橫斷。盤的側壁內噴嘴57引導蝕刻氣入室向晶片之邊以橫越室內裝在多孔晶片載體內的晶片表面。盤55內轉片14及晶片載體稍微傾斜使晶片支承在載體的肋中如有關圖2所說明。

以此方式直接連接一馬達58於轉片14以產生轉片及其裝載的晶片之必要轉動。

須知本文發表在一酸處理機內處理眾多半導體矽晶片之方法，此機經正常結構供濕蝕刻液體使用者。蝕刻氣體供應入室供橫越其中所處理的晶片表面。此所述方法亦可與供應入室的電漿形成氣體之電漿聯合使用。可能轉片相對噴嘴轉動已如前述，惟噴嘴亦可繞裝載晶片堆架的晶片載體旋轉以產生散發蝕刻氣的噴霧氣體來源與轉片及晶片載體所裝晶片間之必要相對旋轉。當然噴嘴及盤與其中其他硬體必須具備能耐強烈蝕刻氣之敗壞影響。

157313 公告本

A7
B7
C7
D7

六、申請專利範圍

1. 在半導體晶片之氣相蝕刻技術上脫除此等晶片上部份氧化物膜之方法，包括：裝載許多此項半導體晶片於一晶片載體內其中晶片相互間隔成面對面關係，供應含無水氟化氫氣的蝕刻氣體在晶片間流動，並暴露部份晶片於蝕刻氣以蝕刻其上氧化物膜部份。
2. 根據申請專利範圍第1項之方法並轉動晶片載體與其中晶片。
3. 根據申請專利範圍第2項之方法，其中係繞一橫越該晶片等伸張的軸旋轉。
4. 根據申請專利範圍第3項之方法，其中晶片係在通過晶片之軸上。
5. 根據申請專利範圍第3項之方法，其中晶片鄰近而與軸隔離。
6. 在半導體晶片之氣相蝕刻技術上脫除此等晶片上部份氧化物膜之方法，包括：裝載許多此項晶片的晶片載體安裝在處理機的盤內之轉片上；供應蝕刻氣於此盤內，並轉動此轉片及載體與晶片等使晶片部份暴露於氣體以蝕刻晶片上的氧化物膜部份。
7. 根據申請專利範圍第6項之方法，其中蝕刻氣含無水氟化氫氣。
8. 根據申請專利範圍第6項之方法，其中蝕刻氣引導向此等衆多晶片之間。
9. 在半導體晶片之氣相蝕刻技術上脫除此等晶片正面中氧化物膜部份之方法，包括：安裝衆多此等晶片相互成間

（請先閱讀背面之注意事項再填寫本頁）

裝
訂
線

六、申請專利範圍

隔而面對面關係，將每一晶片自其背面支承於鄰近其邊之其外周緣處；並供應蝕刻氣於晶片中間及須蝕刻之該部份上。

10. 根據申請專利範圍第9項之方法並暴露晶片之正及反二面部份於蝕刻氣以蝕刻。

11. 在半導體晶片之氣相蝕刻技術上脫除此等晶片上氧化物膜部份之方法，包括：安裝眾多此項半導體相互成間隔的面對面關係；並由眾多噴霧來源供應及導引蝕刻氣朝向許多晶片部份使蝕刻劑在晶片之間流動，且暴露氧化物膜部份於此氣體藉以蝕刻。

12. 根據申請專利範圍第11項之方法並在晶片與某些噴霧來源之間產生相對旋轉運動。

13. 在半導體晶片之氣相蝕刻技術上脫除此等晶片上氧化物膜部份之方法，包括：組集並排列眾多此項晶片相互成間隔對齊及面對面的相對固定關係於一寬鬆而延長的晶片堆架內；豎直移動晶片堆架入一能關閉的盤並限制堆架於盤內；及供應蝕刻氣於盤中使晶片部份暴露於此氣供蝕刻晶片上的氧化物膜部份。

14. 根據申請專利範圍第13項之方法並於至少部份晶片暴露於氣體期間旋轉堆架。

15. 根據申請專利範圍第13項之方法，其中蝕刻氣含一部份無水氟化氫氣。

16. 根據申請專利範圍第13項之方法，其中蝕刻氣不含電漿產生氣體之電漿。

（請先閱讀背面之注意事項再填寫本頁）

裝

訂

線

六、申請專利範圍

17. 一種蝕刻半導體晶片上氧化物膜或層部份之方法，包括：堆積並保持衆多此項晶片使相互成對齊間隔關係；將堆架的晶片裝在一處理機盤內之轉片上，使堆架沿旋轉軸定向俾晶片橫越旋轉軸放置；及噴霧蝕刻氣入盤內朝向晶片之邊，同時轉動轉片與晶片使氣態蝕刻劑移動橫過晶片上氧化物膜部份而產生此等部份之蝕刻。

18. 根據申請專利範圍第17項之蝕刻方法，其中該蝕刻氣之噴霧經引導橫過轉動晶片之表面。

19. 根據申請專利範圍第17項之蝕刻方法，其中該噴霧自衆多地點沿晶片堆架散發。

20. 根據申請專利範圍第17項之蝕刻方法，其中堆架晶片之安裝包括放置該堆架離開轉片之旋轉軸並成間隔關係。

21. 根據申請專利範圍第20項之蝕刻方法，該蝕刻氣之噴霧自鄰近轉片的旋轉軸之位置散發，由其處向外至堆架的晶片上。

22. 根據申請專利範圍第18項之蝕刻方法，該蝕刻氣之噴霧自旋轉軸遠隔的地點散發。

23. 根據申請專利範圍第17項之蝕刻方法，其中該堆架晶片之安裝包括沿轉片之旋轉軸放置堆架晶片及其中之軸延伸過堆架內的晶片。

24. 根據申請專利範圍第17項之蝕刻方法，其中該晶片之堆積與保持包括限制晶片於多孔晶片載體中能容蝕刻氣接近晶片。

25. 在氣相蝕刻矽及類似物之技術上脫除此等晶片上氧化物

（請先閱讀背面之注意事項再填寫本頁）

裝　訂　線

經濟部中央標準局印製

六、申請專利範圍

膜部份之方法，包括：將裝有衆多此項晶片的多孔晶片載體安裝在處理機的盤內；由噴嘴中噴霧蝕刻氣入盤中朝向晶片之邊使蝕刻氣移行横過晶片上氧化物膜部份以產生此等部份之蝕刻；及在晶片載體與噴嘴之間繞一旋轉軸沿伸至晶片堆架之末端而產生相對旋轉。

26. 根據申請專利範圍第25項之方法，其中蝕刻氣之供應自沿晶片堆架之衆多地點處之許多位置與噴嘴散發。

79100730

公告本

- 20 -

23768

ABSTRACT OF DISCLOSURE

Batch processing of semiconductor wafers utilizing a gas phase etching with anhydrous hydrogen fluoride gas flowing between wafers in a wafer carrier. The etching may take place in a bowl with the wafer carrier mounted on a rotor in the closed bowl. The etchant gas may include a small amount of water vapor, along with the anhydrous hydrogen fluoride gas, as may be needed to commence the etching process. The etching may take place with the wafers arranged in a stack in the wafer carrier and extending along or on the rotation axis.

22780-216
D14/0001/v

1A

HF GAS ETCHING OF WAFERS IN AN ACID PROCESSOR

This invention relates to gaseous etching of silicon wafers and more particularly to such etching of batches of wafers carried in linear wafer carriers and revolved in an enclosed chamber.

BACKGROUND OF THE INVENTION

In the processing of semiconductor wafers of silicon and the like in the manufacture of circuit chips, etching of oxide layers or films on the surface of the wafer is an important aspect of the processing.

Much of the wafer processing in the past has utilized a wet etching process which involves the spraying of liquid acids and other liquid chemicals and deionized water onto silicon wafers confined in wafer carriers of plastic capable of withstanding the deteriorating effects of strong chemicals such as acids.

One or more such wafer carriers is carried on a variable speed turntable or rotor in a closed bowl of an acid processor machine. Such a machine has many variable phases to its operation including varying the speed of the rotor, sequentially spraying various liquid processing chemicals, and nitrogen gas for drying the wafers, bowl and rotor between various wet processing phases. One form of acid processor is illustrated and described in U.S. Patent 3,990,462. Also see U.S. Patents 4,609,575; 4,682,615 and 4,691,722 for variations in spray nozzle arrangements and other facilities for wet etch processing. Also see U.S. Patent 4,682,614 for a nearly horizontal machine.

Etching of silicon wafers has been carried out with plasma of certain gases. A number of wafers were disclosed to have been simultaneously etched in U.S. Patent 3,879,597 using plasma techniques.

Some early work in batch etching of SiO_2 with gaesous HF/H_2O was disclosed in an *IBM Technical Disclosure Bulletin,* Vol. 19, No. 7, December, 1976, K. D. Beyer and M. H. Whitehill. A number of wafers in a tray were placed above an HF-solution, then rinsed in DI-water, and finally dipped in a nitric acid solution.

Etching of oxide films on silicon wafers has been accomplished, in recent years, with the use of anhydrous hydrogen fluoride gas. See U.S. Patent 4,749,440. The etchant hydrogen fluoride gas is usually diluted with dry nitrogen gas. A small amount of moisture, either as a vapor mixed with the hydrogen fluoride gas or contained in the oxide film being etched, is necessarily present to react with the oxide in the film to initiate the etching process.

Such previous gas phase etching of oxide films of silicon wafers has been done only on one wafer at a time, in a chamber designed for and carrying only one wafer. See the '440 patent mentioned above and also see application S.N. 020,473, filed March 2, 1987 at the U.S Patent and Trademark Office under common ownership with the present application.

SUMMARY OF THE INVENTION

An object of the present invention is to improve the batch gaseous etching of semiconductor wafers for removing at least portions of the oxide films or layers

from the surfaces thereof to facilitate more rapid processing of such wafers.

A feature of the invention is the method of batch processing of semiconductor wafers including etching of portions of the oxide film or layers thereon with the use of gaseous etchant including anhyrous hydrogen fluoride and within a closed chamber.

Another feature of the invention is the method of processing a multiplicity of silicon wafers carried in a wafer carrier and exposing the wafers to an etchant gas to remove portions of the oxide films on the wafers, while the wafers and carrier are revolved on the turntable or rotor in the closed chamber of an acid processing machine. Wafers are supported from their back sides adjacent the periphery, and are sprayed from sources all along the loose stack of wafers in a wafer carrier. Plasmas of plasma-producing gases are absent.

An advantage obtained is that many semiconductor wafers may be simultaneously etched while they remain in a wafer carrier with which they are commonly carried and transported, and further, the improved gas phase etching may be carried out in equipment already available and in the manufacturing plants of wafer processing companies.

Where herein, the phrase "etchant gas" is used, it is intended to include whatever gas phase chemicals are utilized for etching portions of the oxide films or layers on the faces of the wafers, and such chemicals may include an active gaseous chemical such as anhydrous hydrogen fluoride gas, a diluent gas such as nitrogen gas, and in some instances a quantity of moisture in water vapor form if the water moisture is not contained within the film or oxide layer on the wafer.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an acid processor machine.

Figure 2 is a section view through the bowl and rotor of one form of acid processing machine which is capable of carrying a number of wafer carriers about the periphery of the rotor or turntable.

Figure 3 is a top plan view of the open bowl of another form of acid processor machine capable of carrying out the present invention and showing a single wafer carrier with stacked wafers located substantially concentrically of and on the rotation axis.

Figure 4 is a partial detail section view taken approximately at 4-4 of Figure 3.

Figue 5 is an elevation view of another form of acid processor capable of carrying out the present invention and having its bowl and rotor oriented at a slight angle off horizontal so that the rotation axis is nearly horizontal.

Figure 6 is a detail partial side elevation view of a wafer carrier for holding wafers being processed according to the present invention.

DETAILED SPECIFICATION

In general, Figures 1 and 2 illustrate an acid processing machine capable of use in carrying out the method described herein, the acid processing machine 10 being of the type to mount and carry a multiplicity of

wafer carriers or wafer cassettes 11 in spaced relation to the rotation axis and to carry the wafers therein orbitally around the rotation axis.

Figures 3 and 4 illustrate a different type of acid processing machine which is indicated in general by the numeral 12 and which mounts such a wafer carrier 11, or 11.1 as shown, approximately on the rotation axis of the machine.

In the third form illustrated in Figure 5, the acid processing machine indicated by the numeral 13, is capable of being used to carry out the method set forth herein, and in this instance the wafer carrier 11 is mounted on a rotor 14 revolving about an axis 15 which is merely horizontal, but at a slight angle with the horizontal. All of these three forms of acid processor are capable of being used to carry out the method described herein.

In the acid processor illustrated in Figs. 1 and 2, the machine 10 incorporates a bowl 16 which defines a processing chamber 17 which is closed by the cover 18. The bowl and cover are preferably made of plastic such as Teflon PFA but may be formed of stainless steel. In this form, the rotor 19, also of Teflon PFA or stainless steel, defines a multiplicity of compartments 20, symmetrically disposed around the periphery of the rotor 19 and equidistant from the rotation axis of the rotor which is supported on a shaft 21 and mounted in bearings 22. The compartments 20 of the rotor 19 are tied together by a top plate 23 and a bottom plate 24 and are of such a size as to receive and confine such a wafer carrier 11 loaded with silicon wafers 25. The silicon wafers are arranged in a stack wherein each of the

wafers is aligned with and confronts adjacent wafers, and wherein each of the wafers is oriented transversely of and normal to the rotation axis of rotor 19. The wafer carrier 11 and the wafers 25 therein are spaced from the rotation axis and revolve with the rotor about the rotation axis.

As will be seen in Fig. 6, the wafer carrier is slotted, apertured or foraminous in nature and has an open top 26, which comprises the front of the carrier when it is standing on end as it is mounted in the rotor 19 of the machine. The wafer carrier 11, which is formed of PFA Teflon, otherwise known as the perfluoroalkoxy melt processible plastic which is highly resistant to the deteriorating effect of strong chemicals such as acids, also has an open bottom 27 between the inwardly offset lower portions 28 of the carrier as to support the wafers in grooves 29 which form seats for the wafers as they are carried in the wafer carrier. Between the several grooves 29 are a multiplicity of ribs or teeth 30 which extend from the lower portion entirely upwardly throughout the sidewall so as to keep the wafers in spaced and aligned relation with each other. The sidewall 31 in which the teeth or ribs 30 are incorporated, are provided with a multiplicity of slots 32 to facilitate passage of etchant gas through the wafer carrier in order to obtain access to the wafers 25 confined therein. When the wafer carrier 11 is placed in the rotor, the back sides of the wafers are supported at their edge portions by the ribs 30 so as to expose the entire front or top side of the wafer to the atmosphere in the chamber 17, and epxose substantially all portions of the back sides of the carrier to the atmosphere within the chamber 17.

The wafer carrier 11 also has an end wall consisting of a crossbar 33 which may have any of a number of configurations, and may have flanges 34 for strengthening it. The crossbar 33 extends entirely across the wafer carrier and the sidewalls 31 may be strengthened relative to the crossbar as by gussets 35.

In the machine 10 as seen in Figure 2, a central spray post 36 extends from the cover 18 and extends downwardly at approximately the rotation axis of rotor 19 and along the wafer carrier 11 and the stack of wafers 25 therein. The spray post has a multiplicity of nozzles 37 therein for directing the process gases including the etchant gas onto the wafers as they revolve with the rotor in the bowl 16. Etchant gas and other gases are supplied through a header 37.1 which is connected to several gas lines 38, 38.1 through which gas is supplied to the nozzles 37 for spraying onto the wafers and along the full length of the stack of wafers in the bowl.

The rotor is driven by a variable speed motor 39 which is connected to the shaft 21 as by a drive belt 40. In this form, the shaft 21 has a flow passage 21.1 therein for delivering fluids into the manifold pipes 42 and the nozzles 43. These nozzles 43 are particularly useful in directing rinsing or cleaning fluids such as deionized water for the chamber 17 when desired, and drying gas, such as nitrogen, in order to assure that the inside of the bowl 16 remains dry during processing. An exhaust duct 44 is provided to exhaust gases out of the chamber 17 so that a continuing flow of gas may be provided when desired. A drain 45 is also provided in order to remove rinsing or cleaning fluids during certain cleansing operations as may be needed.

It will be recognized that in the wafer carriers 11 when they are carried on the rotor, the wafers 25 are spaced from each other by open spaces 25.1 so that gases may pass across the faces of the wafers to accomplish the etching process.

The wafer carrier 11 is similar to that illustrated in U.S. Patent 3,961,877, but it should be understood that other similar carriers would be useful in this machine for carrying out the process described and claimed herein.

The paricular etching process is described in considerable detail in U.S. Patent 4,749,440 which is incorporated herein by reference and need not be repeated for an understanding of the present invention. The etchant gases are supplied through the nozzle orifices 37 and are directed toward the edges of the wafers 25 and through the spaces 25.1 between the wafers as to traverse the faces of the wafers and accomplish etching of the oxides on the faces of the wafers. Simultaneous etching of a multiplicity of wafers as carried in the carrier 11 is accomplished because there is a multiplicity of locations at which the gas emanates from the spray post 36, and it will be seen that the orifices 37 are arranged in a row along the face of the spray post 36. Of course as the rotor revolves, the wafers in the several carriers 11 spaced around the periphery of the rotor 19 will be progressively subjected to the spray of etchant gas emanating from the central spray post.

The following TABLE I reports the results obtained in gas phase etching carried out in an acid processor substantially identical to that of Figure 2.

TABLE 1

TESTING SUMMARY

Test #	Time	N_2 l/min.	Vapor cc/min.	HF /min	Oxide Removed	Rotation Speed/RPM	% CV	Particle	Residue
1	5.0'	7.51	3.01	125cc	Cleared			2292	Yes
2	4.0'	7.51	3.01	125cc	Cleared			2572	Yes
3	3.0'	7.51	3.01	125cc	Cleared			1585	Yes
4	1.0'	7.51	3.01	375cc	Cleared			678	Yes
5	20"	7.51	3.01	375cc	269A	(25)	9.3	437	No
6	20"	7.51	3.01	375cc	243A	(17.8)	7.3	311	No
7	20"	7.51	3.01	125cc	36A		1.7	744	No
8	20"	7.51	3.01	125cc	21A		0.8	554	No
9	40"	7.51	3.01	125cc	108A	(5.8)	5.4		No
10	20"	7.51	1.51	125cc			No Etch		
11	60"	7.51	1.51	125cc	270	(27)	10.0		No
12	20"	15.01	1.51	125cc			No Etch		
13	60"	15.01	1.51	125cc	879	(111)	12.7		Yes
14	60"	15.01	1.51	125cc	491	(107)	21.9		Yes

In Figs. 3 and 4 a similar, but slightly different, form of acid processing machine is illustrated, and a slightly different form of wafer carrier, 11.1 is utilized. This wafer carrier 11.1 has additional slots 32.1 and 32.2 so that the sidewalls of the wafer carrier are highly foraminous as to provide minimum restriction to the flow of sprayed etchant gases. The wafer carriers 11 and 11.1 may be used interchangeably in the several forms of machines illustrated herein. It will be seen in the form of processing machine of Figure 3 that the wafers 25 are supported in substantially the same manner in the wafer carrier as in Figure 2 and the

wafers revolve with the carrier 11.1 as indicated by the arrow "a" and about a rotation axis 46 which extends along and through the wafers oriented in the stack. Again, the bowl 47 has a cover 48 as to close the interior chamber 49. Spray of the etchant gas may emanate from one or more of the nozzles 50, 51, and the diluent gases for purging the chamber may be also supplied through one of the nozzles 50,hines illustrated herein. It will be seen in the form of processing machine of Figure 3 that the wafers 25 revolve with the carrier 11.1 as indicated by the arrow "a" and about a rotation axis 46 which extends along and through the wafers oriented in the stack. Again, the bowl 47 has a cover 48 as to close the interior chamber 49. Spray of the etchant gas may emanate from one or more of the nozzles 50, 51, and the diluent gases for purging the chamber may be also supplied through one of the nozzles 50, films or layers that may be on the faces of the wafers.

A duct 53 is provided for allowing the gases to escape as desired in order to provide circulation, and a drain 54 is provided to allow liquids used to clean the inside of the chamber to escape. It should be recognized however, that in the ordinary course of processing the wafers with gas phase etching, no liquid is ordinarily used or sprayed onto the wafers. However, there are some instances in which the etching will be followed by a spray of deionized water for removing particulate.

In the form illustrated in Fig. 5, the bowl 55 is oriented at a nearly horizontal position as to embrace the rotation axis 15 of the rotor 14. An openable cover

56 facilitates obtaining access into the interior 57 of the bowl or chamber. Again, the wafers 25 are oriented in a stack along the rotation axis 15 and in this instance, the wafers are intersected by the rotation axis. Nozzles 57 in the sidewall of the bowl direct etchant gas into the chamber and toward the edges of the wafers as to traverse the faces of the wafers which are carried in the foraminous wafer carrier within the chamber. The rotor 14 and wafer carrier in bowl 55 is slanted slightly as to cause the wafers to be supported in the ribs within the carrier as described in connection with Figure 2.

In this form, a motor 58 is direct-connected to the rotor 14 to produce the necessary rotation of the rotor and the wafers carried thereby.

It will be recognized that there is disclosed herein the method of processing a multiplicity of semiconductor silicon wafers in an acid processing machine which is normally constructed for the use of wet etching liquids. The etchant gases are supplied into the chamber for traversing the faces of the wafers being processed therein. The method described may also be used in connection with plasmas of plasma forming gases supplied into the chamber. It may be that the rotor revolves relative to the nozzles, as illustrated, but the spraying nozzles may also be revolved around the wafer carrier carrying a stack of the wafers as to produce the necessary relative rotation between the sources of the spray gases from which the etchant gas emanates, and the wafers carried by the rotor and wafer carrier. Of course the spray nozzles and the bowls and other hardware therein must be of such a nature as to resist the deteriorating effect of the strong etchant gas.

I CLAIM:

1. In the art of gas phase etching of semiconductor wafers for removing portions of the oxide films on such wafers, the method consisting in

mounting a multiplicity of such semiconductor wafers into a wafer carrier wherein the wafers are in spaced and confronting relation with each other, and supplying etchant gas including anhydrous hydrogen fluoride gas to flow between the wafers and expose portions of the wafers to the etchant gas for etching portions of the oxide films thereon.

2. The method according to claim 1 and revolving the wafer carrier and the wafers therein.

3. The method according to claim 2 wherein the revolving is about an axis extending transversely of said wafers.

4. The method according to claim 3 wherein the wafers are on the axis which passes through the wafers.

5. The method according to claim 3 wherein the wafers are adjacent to and spaced from the axis.

6. In the art of gas phase etching of semiconductor wafers for removing portions of the oxide films on such wafers, the method consisting in

mounting a wafer carrier loaded with a multiplicity of such wafers, onto a rotor in the bowl of a processing machine,

and supplying of etchant gas into the bowl and revolving the rotor and carrier and wafers for exposing portions of the wafers to the gas for etching portions of the oxide films on the wafers.

7. The method according to claim 6 wherein the etchant gas includes anhydrous hydrogen fluoride gas.

8. The method according to claim 6 wherein the etchant gas is directed toward and between a multiplicity of such wafers.

9. In the art of gas phase etching of semiconductor wafers for removing portions of the oxide films from the front sides of such wafers, the method consisting in

mounting a multiplicity of such semiconductor wafers in spaced and confronting relation to each other by supporting each wafer from its back side at its outer perphery adjacent its edge,

and supplying etchant gas between the wafers and onto said portions to be etched.

10. The method according to claim 9 and exposing portions of both the front sides and back sides of the wafers to the etchant gas for etching.

11. In the art of gas phase etching of semiconductor wafers for removing portions of the oxide films on such wafers, the method consisting in

mounting a multiplicity of such semiconductor wafers in spaced and confronting relation with each other

and supplying and directing etchant gas from multiple spray sources and toward portions of a plurality of wafers as to flow the etchant gas between the wafers and expose portions of the oxide films to the gas to be etched thereby.

12. The method according to claim 11 and producing relative rotary movement between the wafers and certain of the spray sources.

13. In the art of gas phase etching of semiconductor wafers for removing portions of the oxide films on such wafers, the method consisting in

assembling and arranging a multiplicity of such wafers into spaced, aligned, and confronting and relatively stationery relation to each other and into a loose and elongate stack of wafers,

moving the stack of wafers endways into a closeable bowl and confining the stack in the bowl,

and supplying etchant gas into the bowl for exposing portions of the wafers to the gas for etching portions of the oxide films on the wafers.

14. The method according to claim 13 and rotating the stack during at least part of the exposing of the wafers to the gas.

15. The method according to claim 13 wherein the etchant gas includes a portion of anhydrous hydrogen fluoride gas.

16. The method according to claim 13 wherein the etchant gas is absent a plasma of a plasma producing gas.

17. A method of etching portions of oxide films or layers on semiconductor wafers, comprising

stacking and retaining a multiplicity of such wafers in aligned and spaced relation with each other,

mounting the stacked wafers onto the rotor in the bowl of a processing machine and orienting the stack along the rotation axis so that the wafers lie transversely of the rotation axis,

and spraying etchant gas into the bowl and toward the edges of the wafers while the rotor and wafers are revolved to cause the gaseous etchant to travel across portions of the oxide films on the wafers and to produce etching of such portions.

18. A method of etching according to claim 17 wherein said spraying of etchant gas is directed across the faces of the revolving wafers.

19. A method of etching according to claim 17 wherein said spraying emanates from a multiplicity of locations along the stack of wafers.

20. A method of etching according to claim 17 wherein the mounting of the stacked wafers includes positioning said stack away from and in spaced relation with the rotation axis of the rotor.

21. A method of etching according to claim 20 and said spraying of etchant gas emanating from a location adjacent the rotation axis of the rotor and outwardly therefrom onto the stacked wafers.

22. A method of etching according to claim 18 and said spraying of etchant gas emanating from locations widely spaced from the rotation axis.

23. A method of etching according to claim 17 wherein said mounting of the stacked wafers includes locating the stacked wafers along the rotation axis of the rotor and wherein the axis extends through the wafers in the stack.

24. A method of etching according to claim 17 wherein said stacking and retaining of wafers includes confining the wafers in a foraminous wafer carrier which allows access by the etchant gas to the wafers.

25. In the art of gas phase etching of silicon and the like for removing portions of the oxide films on such wafers, the method consisting in

mounting a foraminous wafer carrier loaded with a multiplicity of such wafers into the bowl of a processing machine,

spraying from nozzles etchant gas into the bowl and toward the edges of the wafer to cause the etchant gas to travel across portions of the oxide films on the wafers and to produce etching of such portions,

and producing relative rotation between the wafer carrier and nozzles around a rotation axis extending endways of the stack of wafers.

26. A method of etching according to claim 25 wherein the supplying of etchant gas emanates from a multiplicity of locations and nozzles at a multiplicity of locations along the stack of wafers.

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☑ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.